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Accounting for Output Drops in Latin America

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Abstract

This paper evaluates what type of models can account for the recent episodes of output drops in Latin America. I develop an open economy version of the business cycle accounting methodology (Chari, Kehoe, and McGrattan, 2007) in which output fluctuations are decomposed into four sources: total factor productivity (TFP), a labor wedge, a capital wedge, and a bond wedge. The paper shows that the most promising models are the ones that induce fluctuations of TFP and the labor wedge. On the other hand, models of financial frictions that translate into a bond or capital wedge are not successful in explaining output drops in Latin America. The paper also discusses the implications of these results for policy analysis using alternative DSGE models.

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1 Introduction

Emerging economies have more volatile business cycles compared to developed countries.[1] There are many factors that may account for this difference such as the size of the shocks, the structure of the economy, and policy interventions. A key challenge for policymakers is to identify among these elements what are the sources of macroeconomic volatility in order to implement appropriate policy measures to minimize the welfare costs of business cycles. The estimation and simulation of a dynamic stochastic general equilibrium (DSGE) model provides a convenient methodology to evaluate alternative policies in a framework that is immune to the Lucas critique. In the process of formulating a DSGE model, one of the most important questions is, what type of models are relevant to study business cycles in emerging economies? The goal of this paper is to provide an answer to this question using an open economy version of the neoclassical growth model as the starting point. I extend the business cycle account methodology proposed by Chari, Kehoe, and McGrattan (2007) to an open economy, and evaluate what class of models are relevant to study episodes of output drops in Latin American. I consider a sample of six countries: Argentina, Brazil, Chile, Colombia, Mexico, and Peru.

The business cycle accounting methodology constitutes a diagnostic tool that helps to identify what type of models or frictions are relevant to account for business cycle fluctuations. This methodology involves two steps. The first step consists in measuring the gaps or differences between the neoclassical growth model and the data. These deviations are called "wedges" and capture alternative model specifications that can induce discrepancies of the standard neoclassical model from the data. For example, a significant gap in the consumption-leisure first order condition or "labor wedge" can be observed if the economy faces increased distortions in the labor market associated with sticky wages or increases in wage markups because of stronger labor unions.[2] These frictions generate a wedge between the marginal rate of substitution of consumption and leisure and the real wage. The second

[1] For stylized facts of business cycles in emerging economies see Neumeyer and Perri (2005).

[2] Appendix B describes in detail the concept of wedges, showing how can they be linked to DSGE models applied to emerging economies.

step consists in evaluating the quantitative relevance of these gaps to account for specific episodes. For instance, if we consider that labor market frictions might be the main force behind a decline in economic activity, then the labor wedge should be able to account for this fact. To implement this step, the labor wedge is treated as an exogenous shock, and then is fed into the model to evaluate its ability to match the data.

Chari et al. (2005, 2007) apply this methodology to study several episodes, such as the Great Depression, the 1982 U.S. recession, and the 1994 Mexican crisis. This paper applies the business cycle methodology to study episodes of output drops in six Latin American economies.[3] We define output drops as the decline in detrended GDP per capita from peak to trough observed in the late 1990s in Latin America. The exact timing of the output drop episodes and the value of the trend is specific to each country. In this paper, I extend Chari et al. (2007) methodology and consider as a starting point the open economy version of the neoclassical model with four disturbances: total factor productivity, labor wedge, capital wedge, and a bond wedge.[4] I estimate the wedges via maximum likelihood and then assess their ability to match the data.

The paper finds that TFP and the labor wedge account for most of the output drops in Latin America. On the other hand, the capital and the bond wedge have limited success to explain episodes of output drops. This result shows that theoretical models that generate fluctuations of TFP and the labor wedge are going to be successful in explaining episodes of output drops in Latin America. However, models of financial frictions that translate into the capital and the bond wedges are going to have limitations in reproducing these episodes. This is consistent with the work of Chari et al. (2005, 2007)

[3] The advantage of the business cycle accounting approach compared to structural VARs consists in being a theory-based methodology. Using as a starting point the standard neoclassical growth model, it is possible to identify in which margins the model is not performing correctly in order to design proper models capable of explaining specific episodes of business cycles.

[4] Strictly speaking, the TFP shock is a wedge since it measures the gap between GDP and the combination of capital and labor. In the RBC literature initially variations in TFP have been interpreted as technology shocks. More recently, there are several other interpretations that can explain fluctuations in TFP based on misallocation of resources due to distortionary policies. Two examples are the work of Restuccia and Rogerson (2008) and Lagos (2006). For that reason, Chari et al. (2007) label the TFP shock as efficiency wedge.

where they find scant support for the financial accelerator model of Bernanke et al. (1999) during the Great Depression and for models with collateral constraints such as the one used by Mendoza (2006) for the 1994 Mexican crisis.

It is important to clarify that this result does not imply the lack of importance of financial frictions for business cycles. In fact, there is extensive empirical evidence that shows a high correlation between financial crises and economic activity.[5] The results in this paper shed light on the potential mechanisms that could be operating during an episode of output drop. If the deterioration of financial conditions is an important candidate to explain a severe downturn in Latin America, then the results of this paper show that an empirically relevant model of financial frictions should be consistent with significant variations in TFP or the labor wedge.

In the accounting exercise I find that the impact of the labor wedge varies greatly across countries. In particular, the labor wedge is significantly more important in explaining output drops in Argentina, Brazil and Peru. Several distortions might be affecting the efficiency conditions in the labor market in these countries; however, monetary policy is a likely candidate that might explain the behavior of the labor wedge. Monetary policy tends to be more contractionary for these three countries during the episodes of output drops. If we consider a simple financial friction in which labor costs are subject to a working capital constraint, then an increase in the interest rates will raise effective labor costs and decrease employment. Consistent with a theoretical model of a working capital constraint, we observe a high correlation between the labor wedge and the real interest rate.

The structure of the paper is as follows. Section 2 describes in detail the baseline small open economy model. Section 3 explains the estimation and solution method. Section 4 includes a sensitivity analysis to show the robustness of the results. Section 5 concludes.

[5] See Kaminsky and Reinhart (1999).

2 Benchmark Small Open Economy Model

The paper considers a small open economy version of the neoclassical growth model such as in the works of Mendoza (1991), Correia et al. (1995), and Schmitt-Grohé and Uribe (2003). Households maximize the expected discounted utility:

$$E_0 \sum_{t=0}^{\infty} N_t \beta^t \; U(c_t, l_t)$$

subject to a budget constraint, a law of motion for capital accumulation, and an upward-sloping supply of funds for international borrowing:

$$(1+n)b_{t+1} + c_t + i_t \leq (1-\tau_{lt})w_t l_t + (1-\tau_{kt})r_t k_t + (1+\tau_{bt})(1+r_t^*)b_t + T_t \quad (1)$$

$$(1+n)k_{t+1} = (1-\delta)k_t + i_t - \phi(\frac{i_t}{k_t})k_t \quad (2)$$

$$(1+r_t^*) = (1+r^*)(\frac{b_t}{b^*})^{\upsilon} \quad (3)$$

In the utility function N_t is the population size, β is the discount factor, and c_t and l_t are the per capita consumption and labor supply, respectively. In the budget constraint (1) b_t is the international bond, i_t is investment, k_t the stock of capital, w_t the labor wage, r_t the capital rental rate, r_t^* the international interest rate, and T_t the government transfers. All the prices in the budget constraint are multiplied by wedges. The wedges could be interpreted as distortionary taxes in a neoclassical growth model with fiscal policy. $(1-\tau_{lt})$, $(1-\tau_{kt})$, and $(1+\tau_{bt})$ are the labor wedge, capital wedge, and the bond wedge, respectively.[6] Equation (2) is the law of motion for capital. As mentioned in Schmitt-Grohé and Uribe (2003) we need to introduce a

[6] Notice that bond wedge also can be interpreted as a tax on international debt. In this case I assume that the country is a net debtor that pay taxes on interest payments. If it was the case of net creditor, the wedge could be defined as $(1-\tau_{bt})$ to represent a tax on interest income.

capital adjustment cost $\phi(\bullet)$ term to match the volatility of investment with the one observed in the data. Finally we follow Schmitt-Grohé and Uribe (2003) and close the model with an upward-sloping supply of funds (3).[7]

Production is carried out by firms that have access to a technology with constant returns to scale $A_tF(k_t,(1+\gamma)^t l_t)$ which has a labor-augmenting technological progress trend given by $(1+\gamma)$ and stochastic TFP A_t. Firms choose capital and labor to maximize profits $(A_tF(k_t,(1+\gamma)^t l_t) - w_t l_t - r_t k_t)$ each period. The equilibrium conditions of the baseline model can be summarized by the following system of equations:

$$-\frac{U_{lt}}{U_{ct}} = (1-\tau_{lt})A_tF_{lt} \tag{4}$$

$$U_{ct} = \beta E_t[U_{ct+1}(1+r^k_{t+1})] \tag{5}$$

$$1+r^k_{t+1} = (1-\phi'(\frac{\widehat{i}_t}{\widehat{k}_t}))[(1-\tau_{kt+1})A_{t+1}F_{kt+1}+\frac{1}{1-\phi'(\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}})}((1-\delta)-\phi(\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}})+\phi'(\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}})\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}})]$$

$$U_{ct} = \beta E_t[U_{ct+1}(1+\tau_{bt+1})(1+r^*_{t+1})] \tag{6}$$

$$(1+n)(1+\gamma)\widehat{b}_{t+1} = (1+r^*_t)\widehat{b}_t + A_tF(\widehat{k}_t, l_t) - \widehat{i}_t - \widehat{c}_t \tag{7}$$

where the variable $\widehat{x_t}$ denotes that it has been detrended by the rate of technological progress $\widehat{x_t} = x_t/(1+\gamma)^t$ so the system is stationary. Equation (4) is the first order condition for the consumption-leisure decision. Equations (5) and (6) are the Euler equations for capital and bonds and (7) is the resource constraint for the economy. Equations (4) - (7) together with the law of motion of capital, the upward-sloping supply of funds, the exogenous processes for the wedges, and the initial conditions determine the solution to

[7] The role of the upward-sloping supply of funds is to induce stationarity in the model. I solve the model with local methods which rely on the assumption that all variables of the model are stationary. Without the supply of funds the model features a unit root, which is inconsistent with the assumption of stationarity.

the model. Appendix A describes in detail the structure of the benchmark small open economy model.

I follow the approach of Chari et al. (2007) and establish a theoretical equivalence between the wedges in the benchmark small open economy and alternative models commonly used to study emerging economies. For the total factor productivity I follow the studies of Chari et al. (2007) and Christiano et al. (2004) and show that variations in TFP can be generated in a model with financing constraints on imports. The labor wedge can be derived from a model in which firms face a working capital constraint, and the effective labor costs depend on the interest rate as in the work of Neumeyer and Perri (2005). A capital wedge can represent frictions in financial markets such as the financial accelerator model used in the work of Gertler et al. (2007). Finally, a bond wedge could represent distortions in the international capital markets such as a collateral constraint for international borrowing as in the work of Mendoza (2006). This equivalence is not restricted to the models mentioned previously. In fact there are alternative DSGE models that can yield the wedges considered in the baseline model. Even though this methodology does not pin down uniquely which model or mechanism is operating in an economy, it provides guidance regarding the class of models that are supported by the data and could be used for policy analysis.

3 Quantitative Analysis

The estimation involves two stages. In the first stage I calibrate and estimate the parameters of the model. The estimation follows the methodology of McGrattan (1994), Ireland (2004), and Chari et al. (2007). In the second stage, I obtain the realized wedges series for each country given the parameters in the model. By construction, all the wedges are calculated in such a way that when they are feed into the model simultaneously, they perfectly fit the data.[8] Once the wedges are calculated, I feed them one by one into the model to infer the relative importance of competing theories of business cycles in emerging economies. Next, I describe in detail the methodology and the main findings from the accounting procedure.

3.1 Calibration and Estimation

In order to calibrate and estimate the model I assume some functional forms and the stochastic processes for TFP and the wedges. I assume a standard logarithmic utility function:

$$U(c,l) = \log(c) + \psi \log(1-l) \tag{8}$$

The production function is Cobb-Douglas:

$$F(k,l) = k^{\alpha} l^{1-\alpha} \tag{9}$$

The capital adjustment cost is defined by:

$$\phi(\frac{i}{k}) = \frac{a}{2}\left(\frac{i}{k} - \delta - \gamma - n - \gamma n\right)^2 \tag{10}$$

This specification ensures that the adjustment costs are zero along the balanced growth path. I assume that the stochastic processes $Z_t = [\log(A_t/A), \log((1-$

[8] This constraint turns this analysis into an accounting exercise, so Chari et al. (2007) label this procedure "business cycle accounting".

$\tau_{lt})/(1-\tau_l)), \log((1-\tau_{kt})/(1-\tau_k)), \log((1+\tau_{bt})/(1+\tau_b))]$, can be represented by a VAR(1):

$$Z_t = AZ_{t-1} + \varepsilon_t \tag{11}$$

$$A = \begin{bmatrix} \rho_1 & 0 & 0 & 0 \\ 0 & \rho_2 & 0 & 0 \\ 0 & 0 & \rho_3 & 0 \\ 0 & 0 & 0 & \rho_4 \end{bmatrix} V = \begin{bmatrix} \sigma_1 & 0 & 0 & 0 \\ 0 & \sigma_2 & 0 & 0 \\ 0 & 0 & \sigma_3 & 0 \\ 0 & 0 & 0 & \sigma_4 \end{bmatrix}$$

where ε_t is an independent and identically distributed multivariate normal process with mean zero and variance V. I abstract from spillovers between the stochastic processes and assume that the covariance among them is equal to zero.[9]

The vector of parameters is defined as $\Phi' = [\Delta', \Psi']$. The component Δ contains the parameters of the model related to technology, preferences and population growth rate, while Ψ includes the parameters of the stochastic processes embedded in A and V. I adopt the same approach as in Chari et al. (2007) and calibrate the parameters in Δ and estimate the parameters in Ψ with Maximum Likelihood.[10].

For the calibration of the parameters, I match the main features of the data in each country. In cases where there is not enough information, I use standard parameter values used in models applied to emerging economies. The parameter ψ is consistent with the fraction of hours worked in each country. The data sources for total hours is described in Appendix C. The discount factor β in each country is calibrated from the Euler equation (5) at the steady state. For the parameter α I follow Bergoeing et al. (2002) and assume that the labor income share is $1 - \alpha = 0.30$. This value is in the mid-range of the estimates obtained by Gollin (2002) for a cross section

[9] I also conducted the estimation considering spillovers among the wedges as in Chari et al. (2007) and the main conclusions of the paper are not modified.

[10] I calibrate the parameters in the vector Δ since there is a consensus in the literature about their values. An alternative approach is to implement Bayesian methods including priors in the estimation. For a review of this methodology see An and Schorfheide (2007).

of countries.[11] The technological progress rate γ and the population growth rate n are obtained from the average growth rates in each country. For the depreciation rate we assume a standard value $\delta = 0.05$.[12] For the capital adjustment cost parameter "a" I use the same approach as Bernanke et al. (1999) and choose a value consistent with the price elasticity of capital with respect to the investment-capital ratio equal to 0.25. In this model the price of capital is defined as $q = 1/(1 - \phi'(\frac{i}{k}))$. Replacing the adjustment cost function (10), I calibrate the parameter a based in the steady state condition $\eta = a(\delta + \gamma + n + \gamma n)$, where η is the price elasticity of capital. Finally, I assume a highly elastic supply of funds in equation (3) $v = 0.0001$. I consider a small value for this parameter, as in Schmitt-Grohé and Uribe (2001), since the only purpose of this friction is to induce stationarity in the model rather than to capture the behavior of the risk premium. The ratio of foreign bonds to GDP b/y for each country is obtained from Lane and Milesi-Ferretti (2006). Table 1 summarizes the calibrated parameters for all the countries.

For the estimation of the vector Ψ first I log-linearize the equilibrium conditions of the model and then express the solution in the state-space form:

$$X_{t+1} = BX_t + C\epsilon_t$$

$$Y_t = DX_t$$

where $X_t =$[$\log(b_t/b), \log(k_t/k), Z_t$] and $Y_t =$ [$\log(y_t/y), \log(i_t/i), \log(l_t/l)$, $\log(c_t/c)$]. The matrices B, C, and D are going to depend on the vector Ψ, which is the parameter to be maximized in the log-likelihood function. The maximum likelihood estimation consists in obtaining the vector of parameters Ψ in the model which makes 'most likely' to have generated the sample observations. Table 2 reports the estimated parameters with standard errors

[11] Measures of the labor income share obtained from the NIPA tend to be underestimated due to the presence of self-employment. Gollin (2002) corrects the labor income share by this factor and shows that is roughly constant across countries.

[12] The depreciation could also be calibrated from the Euler equation (5) at the steady state taking as given the capital-output ratio. Using the capital stock data from Nehru and Dhareshwar (1993) I find implausible low values for the depreciation rate. I conducted an alternative simulation with these values and the results do not change substantially.

in parenthesis. Compared to the estimation for the US conducted by Chari et al. (2007) I find that the wedges and TFP for all of the Latin American countries tend to be more persistent. This reflects the fact that the wedges are estimated to fit the macroeconomic time series of the sample of Latin American countries, which are more volatile and persistent than the US data.[13]

3.2 Simulation: Accounting for Output drops in Latin America

Once the parameters of the model are calibrated and estimated, we I recover the realized wedges from the data and evaluate their quantitative relevance to account for output drops. Figure 2 shows the wedges in the last sixteen years for all countries. The wedges tend to be procyclical. Consistent with the work of Galí et al. (2007), the implicit distortion measured by the wedges tend to be positively correlated with GDP. Table 4 shows that the statistical correlation is positive for most wedges in the sample period.

Some authors have linked the wedges to policy changes. For instance Ohanian et al. (2008) show that variations in the labor wedge are related to changes in labor taxes over the medium term. Even though tax policy can be an important element in explaining business cycles in emerging economies, here we map the variations in wedges and total factor productivity into frictions generated by models used to study such economies.[14] Next, I assess the impact of TFP and each of the wedges on detrended GDP per capita during

[13]One variable I have omitted in the estimation procedure is the foreign interest rate. Even though this might be an important variable in the determination of business cycles in emerging economies, the estimated direct on output is small in DSGE models. Neumeyer and Perri (2005) find that the US interest rate accounts for 3 percent of output volatility, while Uribe and Yue (2006) find the contribution around 7 percent. Also, both authors show that foreign interest rate spread can explain up to 27 percent of fluctuations in output. In the business cycle accounting exercise the bond wedge can be interpreted as interest rate premium on foreign bonds.

[14]Kamisnky et al. (2004) show that fiscal policy tends to be procyclical in emerging economies which exacerbates their business cycles. For an accounting exercise considering fiscal policy see Meza (2008).

episodes of output drops.[15][16]

Figure 3 displays the impact of TFP on output during the sample period. In the baseline model TFP can account for at least 50 percent of the output decline in all six countries. This is consistent with the result of Kehoe and Prescott (2002) that shows how drops in TFP can account for declines in GDP per capita in several countries. This decline in output coincides with episodes of sudden stops and currency crisis. Most of the countries were affected directly by sudden stops episodes triggered by the currency crises in Asia in 1997, Russia in 1998, Brazil 1999, and Argentina 2002.

Kehoe and Ruhl (2008) and Mendoza (2006) have already developed quantitative models to account for one episode of sudden stop: the Mexican crisis of 1994. These authors propose models with a host of frictions in order to capture the decline of TFP during a sudden stop. The open-economy business cycle accounting exercise developed in this paper is complementary to those studies. The results applied to the group of six Latin American countries show that TFP is a key variable behind the decline in output during a sudden stop. In Appendix B I lay out a simple model that can generate fluctuations in TFP through variations in the price of imports and the international interest rate. The model shares some features with the one proposed by Mendoza (2006).

Figure 4 depicts the impact of the labor wedge on GDP. The simulations show that the labor wedge is successful to account for output drops in Argentina, Brazil, and Peru. In these countries the labor wedge explains between 20 and 80 percent of the decline in GDP. There are several frictions that can induce a labor wedge in the consumption-leisure first order condition. For instance, Cole and Ohanian (2004) and Mulligan (2002) discuss how variations in the labor wedge can be generated by changes in labor regulations. For this sample of Latin American countries, it is unlikely that changes in labor regulations induced variations in the labor wedge. A job security index for Latin America elaborated by Heckman and Pages (2000)

[15] The dynamics for the rest of the variables such as investment, employment, and consumption can be provided upon request.

[16] I define output drop as the contraction experienced by country from peak to trough of detrended GDP per capita. An output drop does not necessarily coincides with the concept of a recession. A country can experience a positive GDP per capita growth but below trend and still have and output drop.

shows that on average the burden of labor regulation related to job security was either reduced or remained constant during the 1990s. In contrast, for the same period of time the labor wedge suggests a deterioration in the efficiency of labor markets in Latin America.

An alternative friction that can generate variations of the labor wedge in the short-run is the presence of a working capital constraint. Under this friction, firms have to borrow in advance to pay for the labor costs. With this assumption total labor costs will depend not only on the wage rate but also on the interest rate. Hence, variations in the interest rate will induce changes in the labor wedge, and will affect the consumption-leisure efficiency condition. Neumeyer and Perri (2005) and Uribe and Yue (2006) use this mechanism to study the impact of international interest rates on business cycles in a small open economy.

Figure 5 plots the labor wedge, the output prediction using the labor wedge, and the real interest rate. The figure shows a negative correlation between the real interest rate and the simulated output using only the labor wedge. Countries that exhibit the highest increase in the real interest rate also show the largest decline in output due to the labor wedge. This pattern of real interest rates and output suggests that a friction like a working capital constraint is a promising way to account for the relevance of the labor wedge in this group of emerging economies. In Appendix B I show how a working capital constraint model is equivalent to the benchmark small open economy model with a labor wedge.

Figure 6 plots the predictions of the model with the capital wedge. In the most simple model, a capital wedge can be generated by a tax on capital income. This type of tax distorts the consumption-saving decision and will affect the efficiency condition stated by the Euler equation. In alternative models, the capital wedge can be generated by imperfections in financial markets such as borrowing constraints or costs of enforcing financial contracts.

Figure 6 shows that the capital wedge generates either constant path for output or an economic boom. This result suggests that frictions that translate into a capital wedge are not going to be successful to explain episodes of output drops. For instance, the business cycle accounting model indicates that the financial accelerator model of Bernanke et al. (1999) will not able to account for the observed decline in output in the main Latin American economies. Appendix B shows the equivalence between the model by Bernanke et al. (1999) and the benchmark model with a capital wedge.

The lack of quantitative relevance of the capital wedge has important implications for policy analysis using DSGE models. Gertler et al. (2007) and Céspedes et al. (2004) apply the model proposed by Bernanke et al. (1999) to evaluate alternative monetary rules or exchange rate regimes in an economy with foreign currency liabilities.[17] In their papers, they find that monetary policy rules that allow a floating exchange rate outperform a fixed exchange rate regime.[18] Nevertheless, the same model applied to the case of Latin American economies could provide misleading results. To the extent that the Latin American data does not support a model that generates a capital wedge, such as the one of Bernanke et al. (1999), that policy analysis is not appropriate to evaluate the benefits of alternative monetary and exchange rate regimes.

This result cannot be interpreted as the lack of relevance of financial factors in determining the pattern of business cycles in Latin America. In fact, Kaminsky and Reinhart (1999) show that there is a strong correlation between business cycles and financial crises in emerging economies. Instead, the business cycle accounting approach suggests that if a researcher wants to introduce a financial friction into the model, it should be reflected either in TFP or the labor wedge. Braggion et al. (2007) follow this strategy and introduce a working capital constraint on labor costs and on intermediate imported inputs to model financial frictions in an emerging economy. In addition, a fraction of the capital stock is accepted as a collateral for the loan on imported inputs. When there is a sudden stop of capital flows, these financial constraints generate a variation in TFP and the labor wedge. The optimal policy in this environment is to stabilize the exchange rate in the short-run and then set the interest rates as low as possible. This result is the opposite from the policy prescription derived using the financial accelerator model of Bernanke et al. (1999). Furthermore, the Braggion et al. (2007)

[17] In particular, Gertler et al. (2007) find that the costly state verification friction can account for half of the output decline observed during the Korean financial crisis. This contrasts with our result in which the capital wedge, which is consistent with the costly state verification model, is unable to generate output drops.

[18] The fixed exchange rate regime is compared against a Taylor rule in the case of Gertler et al. (2007) and a strict inflation targeting regime in Céspedes et al. (2004).

model not only is consistent with the relevant wedges observed in the data, but also the theoretical optimal monetary policy prescription is similar to the observed pattern of policy rates during a sudden stop.

Figure 7 displays the simulation of the model considering only the bond wedge. This wedge can be generated by several frictions in international transactions. In the simplest case, the bond wedge can represent an exogenous risk premium in international bonds as in Neumeyer and Perri (2005). Alternatively, this wedge can be generated introducing a collateral constraint for international borrowing as in the work Mendoza (2006). In that type of model, lenders require households to use a fraction of their domestic assets as collateral for international borrowing. As is shown in Appendix B, when this constraint binds, it generates an endogenous risk premium equivalent to the bond wedge. Figure 7 shows that for most of the countries, the bond wedge is not able to reproduce the episodes of output drops.

Two exceptions are the cases of Chile and Mexico. In both countries we observe that the bond wedge can explain to some extent the decline in output. However, it is important to notice that the output drop is generated by a decline in the bond wedge. This implies that a loosening of the borrowing constraint would produce and output drop, a result that is at odds with what we observe in data. The output contraction is generated by the wealth effects on labor supply. Neumeyer and Perri (2005) show that under a Cobb-Douglas utility function, a decrease in the international interest rate will increase both consumption and leisure. This will reduce the labor supply, and hence generate a contraction in output.

Chari et al. (2005) also find a similar conclusion regarding the relevance of a collateral constraint friction during the 1994 Mexican crisis. Following the business cycle accounting approach, they establish a theoretical equivalence between the collateral constraint and a variable labeled "government consumption wedge".[19] In their model a tightening of the constraint is equivalent to an increase in this wedge. In a model calibrated for Mexico they show that a tightening of the collateral constraint increases output, the opposite of what happened during the Mexican crisis. This results leads them to conclude that the collateral constraint is not an appropriate friction to model

[19] Chari et al. (20005) compute the government consumption wedge as the sum of net exports and government consumption.

a sudden stop of capital flows. In this paper, I arrive at the same conclusion using an alternative specification in which the collateral constraint is reflected in the bond wedge. The limited relevance of a model with collateral constraints not only holds for the 1994 Mexican crisis, but also for several other episodes of sudden stops experienced by Latin American economies.

Table 3 summarizes the results from the business cycle accounting exercise. For all of the countries, TFP can explain at least 50 percent of the output drop. The labor wedge is successful to explain between 20 and 80 percent of the decline of output in Argentina, Brazil, and Peru. The capital and the bond wedge have a very limited contribution to output drops in this sample of Latin American countries. The outcome of the business cycle accounting for Latin America, suggests that the most prominent theories of business cycles should be consistent with variations of TFP and the labor wedge. Models of financial frictions that translate into the capital or the bond wedge are not supported by the data, and hence are not good candidates to explain business cycles in Latin America.

Table 4 and 5 extend the analysis to a larger sample in each country, arriving at the same conclusion. Table 4 shows the properties of the wedges. TFP, the labor wedge, and the capital wedge are positively correlated with GDP. If we interpret the wedges as implicit distortions to the efficiency conditions in the model, we observe that there is a loss in efficiency during recessions. This is consistent with the work of Galí et al. (2007) who show that the labor wedge tends to be large during recessions.[20] On the other hand, the bond wedge is negatively correlated with GDP. In a standard small open economy model, the bond wedge can represent a risk premium on international bonds. Considering this interpretation, the data show that the risk premium is higher during periods of output decline. This is consistent with the observation of Neumeyer and Perri (2005) and Uribe and Yue (2006) that the market risk premium is negatively correlated with GDP.[21]

Table 5 shows the correlation of the model prediction for each wedge with

[20]According to this view, there are potential welfare gains of stabilizing the business cycle to the extent that it reduces the efficiency losses measured by the wedges.

[21]It is important to notice that the bond wedge captures all type of imperfections that prevent countries to borrow or save according to the Euler equation. The market risk premium for international bonds is one factor among others that might be influencing the behavior of the bond wedge.

GDP. This table supports the results previously found in individual episodes of output drops. Fluctuations in output are primarily driven by the TFP and the labor wedge, while there is a limited role for the capital and bond wedge. Next, I conduct a sensitivity analysis to evaluate the robustness of the results to alternative functional forms and parametrizations.

4 Sensitivity Analysis

In this section I evaluate the robustness of the results to alternative specifications. The main conclusions obtained in the benchmark model do not change. The two most important factors to account for business cycles are TFP and the labor wedge. The capital and bond wedge have a limited role in explaining output drops. I conduct the sensitivity analysis in three steps. First, I evaluate the model with an alternative coefficient of risk aversion. Second, I consider a version of the benchmark model without capital adjustment costs. Finally, I introduce variable capital utilization. For all these specifications I reestimate the stochastic process for the wedges and TFP and then simulate the model to assess the impact of each of these factors. In all these cases the main results of the benchmark model go through. For space considerations here I report the sensitivity analysis for Argentina. However, the results also hold for the rest of the countries.[22]

4.1 High Risk Aversion Coefficient

I evaluate how the results change to an alternative coefficient of risk aversion. In particular, I assume the following momentary utility function:

$$U(c,l) = \frac{\left[(c)(1-l)^{\psi}\right]^{1-\sigma} - 1}{1-\sigma} \tag{12}$$

For the coefficient of risk aversion I follow King and Rebelo (1999) and set $\sigma = 3$. Qualitatively, panels a and b in figure 3 show that output drops

[22] The simulations for the other countries are available upon request.

continue to be explained mostly by TFP and the labor wedge, and there is limited role for the capital and bond wedge. Quantitatively, there is a small increase in the importance of TFP to account for output drops. In the benchmark case, TFP explains 73 percent of the output drop, while in a model with high risk aversion TFP is able to explain 75 percent of the decline in output. The intuition for this result lies in the changes of labor supply to alternative degrees of intertemporal rate of substitution. A higher risk aversion coefficient increases the elasticity of labor supply.[23] This property of the utility function implies that labor will react more TFP, which in turn generates a greater response of output to changes in TFP. Even though the response of output to TFP is greater in this alternative specification, the effect is quantitatively small.

4.2 No Adjustment Costs

I consider an alternative economy in which investment is not subject to adjustment costs. I recalibrate the model setting $a = 0$ in the adjustment cost function (10). Panels c and d in figure 3 show the simulation of the model without adjustment costs. For this specification, TFP and the labor wedge continue to be relevant to explain the episode of output drop. On the other hand, the capital wedge and the bond wedge fail to predict the downturn experienced in Argentina. With no adjustment costs there is a greater effect of TFP on GDP and the role of the labor wedge is much more limited. Intuitively, in the model without adjustment costs output reacts more to TFP mainly due to the variation of investment. With no adjustment cost, the investment reacts instantaneously to TFP, increasing the stock of capital and output in the next period after the shock. In this version of model still is the case that both TFP and the labor wedge continue to be the leading elements in accounting for the decline in output.[24]

[23] See Correia et al. (1995) for an analysis on the impact of the intertemporal elasticity of substitution on labor supply.

[24] Chari et al. (2007) discuss the implications of alternative parametrizations of the adjustment cost function in the business cycle accounting methodology. They found that assuming high adjustment costs the investment wedge is able to account for a small fraction of the decline during the Great Depression and the U.S. 1982 recession. In the open economy setting, alternative assumptions for the investment adjustment cost do not increase the relevance of the intertemporal wedges.

4.3 Variable Capital Utilization

In the baseline model, we assumed a standard Cobb-Douglas production function. A more realistic assumption is that capital is utilized at different rates during the business cycle. I add to the baseline model an additional variable u_t which measures the utilization rate of capital. The new production function is $F(u_t k_t, l_t) = (u_t k_t)^\alpha l_t^{1-\alpha}$. I assume that the depreciation rate will depend on the utilization rate according to the function proposed by Greenwood et al. (1988):

$$\delta(u_t) = \frac{\chi}{1+\xi} u_t^{1+\xi} \tag{13}$$

In this function I set χ and ξ such that they match the depreciation rate at the steady state.[25] Panels e and f show that the results of the baseline model are robust to this extension. The leading factors accounting for output drops continue to be TFP and the labor wedge. In principle, the capital utilization rate amplifies the response of the model for a given TFP shock.[26] However, the estimated TFP with this alternative model displays a smaller decline compared with the benchmark model.[27] The simulation of this small decline of TFP in a model with variable capital utilization turns out to be quantitatively similar to the simulation of the standard TFP measure in the benchmark model.

5 Concluding Remarks

This paper evaluates which class of models are relevant to explain business cycles in Latin America. In particular, I apply an open economy version of the business cycle accounting methodology to study episodes of output drops experienced recently in Latin America. The methodology shows that the most promising models are the ones that generate fluctuations in TFP

[25] In addition, to be consistent with Greenwood et al. (1988) I set the restriction $\chi = (1+\xi)\overline{\delta}$. Assumming a depreciation rate $\delta = 0.05$ leads to $\xi = 1.04$. This is in the mid-range of the estimates of Basu and Kimball (1997) and similar to the value used for Mexico in Mendoza (2006).

[26] See King and Rebelo (1999).

[27] See Chari et al. (2007) for a discussion of the impact of variable capital utilization rate on the measured TFP.

and the labor wedge. On the other hand, models of financial frictions that translate into a bond or capital wedge are not successful in explaining output drops. This last result has important implications for policy analysis with DSGE models. Alternative strategies to model financial frictions lead to very different policy recommendations. A model of financial frictions that generates a capital wedge such as the one by Gertler et. al (2007) suggests that it is inefficient to stabilize the exchange rate. In contrast, a model with a financial friction that generates variations in TFP and the labor wedge, as in the work of Braggion et al. (2007), some exchange rate intervention is optimal. The result from the business cycle accounting suggests that this last type of model is empirically relevant to analyze alternative monetary policies in Latin America.

This paper can be extended in several dimensions. For instance, I could construct estimates of labor taxes in Latin America and compared them against the labor wedge as in Ohanian et al. (2008). That exercise can help to understand to what extent the wedges represent distortions in the economy such as taxes or alternative model specifications. In addition, I could used the labor wedges to measure the welfare costs of business cycles as in the work of Galí et al. (2007). Moreover, identifying what factors drive the labor wedge across countries could shed light regarding the policy options to reduce the welfare costs of business cycles. For instance, if a working capital constraint is the main determinant of the labor wedge, then there is an important role for monetary policy to reduce this wedge and prevent efficiency losses over the business cycle.

Appendix A: Benchmark Small Open Economy Model

This appendix describes the equilibrium conditions for the benchmark small open economy neoclassical growth model

A.1. Households

The economy is populated by a continuum of households that maximize the expected discounted lifetime utility:

$$E_0 \sum_{t=0}^{\infty} N_t \beta^t \, U(c_t, l_t)$$

subject to a budget constraint, a law of motion for capital accumulation, and an upward sloping supply of funds for international borrowing:

$$(1+n)b_{t+1}+c_t+i_t \leq (1-\tau_{lt})w_t l_t+(1-\tau_{kt})r_t k_t+(1+\tau_{bt})(1+r_t^*)b_t+T_t \quad (A.1)$$

$$(1+n)k_{t+1} = (1-\delta)k_t + i_t - \phi(\frac{i_t}{k_t})k_t \quad (A.2)$$

$$(1+r_t^*) = (1+r^*)(\frac{b_t}{b^*})^{\upsilon} \quad (A.3)$$

where N_t is the population size, β is the discount factor, and c_t and l_t are the per capita consumption and labor supply, respectively. In the budget constraint (A.1) b_t is the international bond, i_t is the amount of investment, k_t is the stock of capital, w_t the labor wage, r_t the capital rental rate, r_t^* the international interest rate, and T_t the government transfers. Finally $(1-\tau_{lt})$, $(1-\tau_{kt})$, and $(1+\tau_{bt})$ are the labor wedge, capital wedge, and bond wedge, respectively.

A.2. Firms

Firms maximize their profits each period:

$$\underset{k,l}{Max} \;\; y_t - w_t l_t - r_t k_t$$

subject to the production function:

$$y_t = A_t F(k_t, (1+\gamma)^t l_t) \tag{A.4}$$

where A_t is the total factor productivity (TFP) and $(1+\gamma)$ a labor-augmenting technological progress. The first order conditions are:

$$w_t = A_t F_{lt} \tag{A.5}$$

$$r_t = A_t F_{kt} \tag{A.6}$$

A.3. Government

The government follows a balanced budget policy, and finances the transfers with distortionary taxes:

$$T_t = \tau_{kt} r k_t + \tau_{lt} w_t l_t - \tau_{bt}(1 + r_t^*) b_t \tag{A.7}$$

A.4. Exogenous Shocks

The exogenous variables A_t, $(1-\tau_{lt})$, $(1-\tau_{kt})$, and $(1+\tau_{bt})$ follow an AR(1) process:

$$Log(A_t) = (1-\rho^A)\log(A) + \rho^A \log(A_{t-1}) + \varepsilon_t^A \tag{A.8}$$

$$Log(1-\tau_{lt}) = (1-\rho^L)\log(1-\tau_l) + \rho^L \log(1-\tau_{lt-1}) + \varepsilon_t^L \tag{A.9}$$

$$Log(1-\tau_{kt}) = (1-\rho^K)\log(1-\tau_k) + \rho^K \log(1-\tau_{kt-1}) + \varepsilon_t^K \qquad \text{(A.10)}$$

$$Log(1+\tau_{bt}) = (1-\rho^B)\log(1-\tau_b) + \rho^B \log(1+\tau_{bt-1}) + \varepsilon_t^B \qquad \text{(A.11)}$$

A.5. Equilibrium Conditions

The solution to the competitive equilibrium problem can be summarized by the following conditions:

$$-\frac{U_{lt}}{U_{ct}} = (1-\tau_{lt})A_t F_{lt} \qquad \text{(A.12)}$$

$$U_{ct} = \beta E_t[U_{ct+1}(1+r_{t+1}^k)] \qquad \text{(A.13)}$$

$$1+r_{t+1}^k = (1-\phi'(\frac{\widehat{i}_t}{\widehat{k}_t}))[(1-\tau_{kt+1})A_{t+1}F_{kt+1} + \frac{1}{1-\phi'(\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}})}((1-\delta)-\phi(\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}})+\phi'(\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}})\frac{\widehat{i}_{t+1}}{\widehat{k}_{t+1}})]$$

$$U_{ct} = \beta E_t[U_{ct+1}(1+\tau_{bt+1})(1+r_{t+1}^*)] \qquad \text{(A.14)}$$

$$(1+n)(1+\gamma)\widehat{b}_{t+1} = (1+r_t^*)\widehat{b}_t + A_t F(\widehat{k}_t, l_t) - \widehat{i}_t - \widehat{c}_t \qquad \text{(A.15)}$$

where $\widehat{x_t}$ denotes a variable detrended by the rate of technological progress: $\widehat{x_t} = x_t/(1+\gamma)^t$. Condition (A.12) determines the allocation between consumption and leisure. Conditions (A.13) and (A.14) are the Euler equations for capital and the international bond, respectively. Finally, equation (A.15) is the law of motion for the international bond.

An equilibrium for this economy is a set of (i) Prices: $\{w_t,\ r_t, r_t^*\}$, and (ii) Allocations: $\{c_t, i_t, l_t, k_t, b_t\}$ such that conditions (A.2), (A.3), (A.12) - (A.15) hold, given the exogenous process $\{A_t, (1-\tau_{lt}), (1-\tau_{kt}), (1+\tau_{bt})\}$, and initial conditions $\{b_0, k_0\}$.

A.6. Steady State

Given the functional forms (8) and (9) we calibrate the parameters of the model to be consistent with the steady state:

$$(1-\alpha)\frac{\overline{y}}{\overline{l}}(1-\overline{\tau_{lt}}) = \psi\frac{\overline{c}}{1-\overline{l}} \tag{A.16}$$

$$1 = \frac{\beta}{(1+\gamma)}(\alpha(1-\overline{\tau_{kt}})\frac{\overline{y}}{\overline{k}} + 1 - \delta) \tag{A.17}$$

$$1 = \frac{\beta}{(1+\gamma)}(1+\overline{r}^{*})(1-\overline{\tau}_{b}) \tag{A.18}$$

$$\frac{\overline{k}}{\overline{y}}(\gamma+\eta+\gamma\eta+\delta) = \frac{\overline{i}}{\overline{y}} \tag{A.19}$$

$$\frac{\overline{b}}{\overline{y}}(\gamma+\eta+\gamma\eta+\delta) = \frac{(\overline{y}-\overline{i}-\overline{c})}{\overline{y}} = \frac{\overline{nx}}{\overline{y}} \tag{A.20}$$

The parameters in table 1 are consistent with the system of equations (A.16)-(A.20).

Appendix B: Equivalence Between Wedges and Theoretical Models

This appendix describes the equivalence between several models applied to small open economies and the benchmark model with TFP and the wedges. Rather than deriving the detailed model I present the key first order conditions that can be mapped into TFP and wedges of the business cycle accounting model. The appendix mentions the references so the reader can access the derivation of the equilibrium conditions in each detailed model.

B.1. Total Factor Productivity

It is possible to generate endogenous fluctuations of TFP in a small open economy model introducing a working capital constraint affecting intermediate imported inputs. Christiano et al. (2004) use this assumption in a small open economy to study the impact of monetary policy during a sudden stop. According to this mechanism even though there is no technological change in the economy, measured TFP will change due to variations of the international interest rate and import prices. In this section, based on Chari et al. (2007), I sketch a simple two-sector economy model in which the production of tradable and non-tradable goods will be subject to a working capital constraint on imported inputs. The main result of this model is that measured TFP in a Cobb-Douglas production function is going to be a function of import prices and the international interest rate.

The final good producer has a production function defined by $q_t = (q_t^T)^{\phi}(q_t^N)^{1-\phi}$, where q_t^T and q_t^N are the gross output in the tradable and non-tradable sector, respectively. The goal of this firm is to maximize profits:

$$\underset{q_T, q_N}{Max} \quad q_t - p_t^T q_t^T - p_t^N q_t^N$$

The gross output in each of the sectors is produced according to the following production function: $q_t^i = (m_{it})^{\theta_i}(z_{it})^{1-\theta_i}$ for $i = T, N$, where m_{it} and z_{it} are the intermediate imported input and the value-added good. In each sector the intermediate imported input will be subject to a working capital constraint. The problem for each sector is:

$$\underset{z_i,m_i}{Max} \;\; p_t^i q_t^i - v_t z_{it} - R_t p_t^m m_{it}$$

where v_t, p_t^m, and R_t are the prices of the valued added good, the price of imported inputs, and the foreign interest rate. Finally, the value-added good sector has the production function $z_t = (k_t)^\alpha (l_t)^{1-\alpha}$. This firm will also maximize profits:

$$\underset{k,l}{Max} \;\; v_t z_t - w_t l_t - r_t k_t$$

GDP in this economy is defined by $y_t = q_t - p_t^m(m_{Tt} + m_{Nt})$. In equilibrium, the production function of the of the economy can be expressed in the following way:

$$y_t = G(R_t, p_t^m)(k_t)^\alpha (l_t)^{1-\alpha}$$

In particular, if we assume the same income shares for both sectors, $\theta_T = \theta_N = \theta$, then the function $G(\bullet)$ is defined by:

$$G(R_t^*, p_t^m) = [\phi^\phi (1-\phi)^{(1-\phi)} \theta^\theta]^{\frac{1}{1-\theta}} \left(\frac{1}{R_t^*}\right)^{\frac{\theta}{1-\theta}} \left(\frac{1}{p_t^m}\right)^{\frac{\theta}{1-\theta}} [1 - \theta(\frac{\phi}{R_t^*} + \frac{1-\phi}{R_t^*})]$$

The allocations in this economy and the benchmark model are the same if the following conditions hold:

$$A_t = G(R_t^*, p_t^m)$$

$$(1 - \tau_{lt}) = \frac{A_t}{v_t}$$

$$(1 - \tau_{kt}) = \frac{A_t}{v_t}$$

Notice that even though there are no technology changes in the production of the value added good, fluctuations in the international interest rate and the import prices will be interpreted as changes in TFP in the benchmark model.

B.2. Labor Wedge

A labor wedge can be generated in a small open economy model where firms face a working capital constraint on labor. Neumeyer and Perri (2005) introduce this friction to study the impact of international interest rates on business cycles in emerging economies. In their model, firms have to borrow in advance a fraction θ of the labor costs. The total labor costs will depend not only on wage rate w_t but also on the gross interest rate R_t due to the working capital constraint. The labor costs will be defined as $[1 + (R_t - 1)\theta]w_t l_t$. The goal of the firm is to maximize profits:

$$\underset{k,l}{Max} \quad y_t - w_t l_t - r_t k_t - (R_t - 1)\theta w_t l_t$$

The consumption-leisure efficiency condition is given by:

$$-\frac{U_{lt}}{U_{ct}} = \frac{1}{1 + \theta(R_t - 1)} A_t F_{lt}$$

The allocations in this economy and the benchmark model are the same if:

$$(1 - \tau_{lt}) = \frac{1}{1 + \theta(R_t - 1)}$$

B.3. Capital Wedge

Gertler et al. (2007) apply the financial accelerator model proposed by Bernanke et al. (1999) to study the role of financial frictions during the 1997-1998 Korean crisis. In this section, I reproduce the main equations derived in

Christiano and Jonas (2006) where they show that the financial accelerator model generates a capital wedge. The key insight of this financial friction is that lenders have to engage in agency costs in order to monitor the projects due to a problem of asymmetric information. This costs will depend inversely in the amount of resources that the entrepreneurs contribute to finance their own project. The more an entrepreneur finance their projects with own resources, the lower the incidence of asymmetric information problems. Due to this friction, the lender is compensated for the agency costs according the following condition:

$$1 + \widetilde{r}^k_{t+1} = (1 + \chi(\frac{n_{t+1}}{q_t k_{t+1}}))(1 + r^*) \tag{B.1}$$

where n_{t+1}, q_t, and k_{t+1} are the networth of the firm, the price of capital, and the capital stock, respectively. The function $\chi(\bullet)$ depends negatively on the ratio of networth to assets. In equilibrium the expected return on capital should be equal to the riskless interest rate $1+r^*$ adjusted for the risk premium $\chi(\bullet)$. In addition, the standard Euler equation holds for households:

$$1 = \beta E_t[\frac{U_{ct+1}}{U_{ct}}(1 + r^*)] \tag{B.2}$$

Combining (B.1) and (B.2) we obtain the following condition:

$$1 = \beta E_t[\frac{U_{ct+1}}{U_{ct}} \frac{1 + \widetilde{r}^k_{t+1}}{(1 + \chi(\frac{n_{t+1}}{q_t k_{t+1}}))}]$$

the allocation in this economy will coincide with the benchmark economy if the following conditions hold:

$$1 + r^k_t = \frac{1 + \widetilde{r}^k_t}{(1 + \chi(\frac{n_t}{q_{t-1} k_t}))} \tag{B.3}$$

$$T_t = T^*_t - M_t \tag{B.4}$$

Condition (B.3) states that return on capital net of taxes in the benchmark model, $1 + r^k_t$, should be equal to the return on capital in the model with financial frictions adjusted by the risk premium. This equation defines implicitly the value of the capital wedge in the benchmark model. In addition, the transfers T_t in the benchmark model should be adjusted for the consumption of entrepreneurs and the monitoring costs M_t.

B.4. Bond Wedge

Mendoza (2006) uses a collateral constraint model to study sudden stops in emerging economies. This constraint states that households can borrow in international capital markets only a fraction κ of their assets:

$$b_{t+1} \geqslant \kappa q_t k_{t+1} \tag{B.5}$$

In the constraint (B.5) b_{t+1} is the international bond, q_t the price of capital, and k_{t+1} the capital stock, respectively. The Lagrange multiplier associated with (B.5) is η_t. In this model the constraint will lead to the following Euler equations for capital and international bonds:

$$1 = \beta E_t[\frac{U_{ct+1}}{U_{ct} - \eta_t}(1 + \widetilde{r}^*_{t+1})]$$
$$1 = \beta E_t[\frac{U_{ct+1}}{U_{ct} - \kappa\eta_t}(1 + \widetilde{r}^k_{t+1})]$$

where $\widetilde{r}^*_{t+1}$ and $\widetilde{r}^k_{t+1}$ denote the return on bonds and capital in the economy with collateral constraint, respectively. The allocations in the economy with a collateral constraint and the benchmark economy are the same if the following conditions hold:

$$\frac{1 + \tau_{bt}}{U_{ct-1}} = \frac{1}{U_{ct-1} - \eta_{t-1}} \tag{B.6}$$
$$\frac{1 + r^k_t}{U_{ct-1}} = \frac{1 + \widetilde{r}^k_t}{U_{ct-1} - \kappa\eta_{t-1}} \tag{B.7}$$

Equation (B.6) define implicitly the bond wedge $1 + \tau_{bt}$ as a function of lagged marginal utility of consumption and the Lagrange multiplier of the collateral constraint. In addition, the capital wedge has to satisfy (B.7).[28]

[28] Notice that in (B.7) the return on capital in the benchmark economy $1+r^k_t$ will depend

Appendix C: Data Sources

C.1. Sample Period

The sample period for the maximum likelihood estimation in each country is shown in the following table:

Country	**Sample Period**
Argentina	1974-2006
Brazil	1991-2006
Colombia	1984-2006
Chile	1975-2006
Mexico	1991-2006
Peru	1991-2006

C.2. National Accounts

For all countries we used annual data on GDP, consumption, investment and investment in constant prices. For Argentina the series are from Instituto Nacional de Estadística y Censos (INDEC) and Penn World Table 6.2 (PWT). For Brazil the series are from Instituto Brasileiro de Geografia e Estatística (IBGE) and the Central Bank of Brazil. For Chile the series are from the Central Bank of Chile. For Colombia the series are from Departamento Administrativo Nacional de Estadística (DANE). For Mexico the series are obtained from OECD.stat. For Peru the series are obtained from the Instituto Nacional de Estadística e Informatica (INEI) and the Central Bank of Peru.

C.3. Employment

For the maximum likelihood estimation I used total employment. For Argentina the series are obtained from INDEC. For Brazil the series are from IBGE and ILO LABORSTA. For Chile the series are from the Central Bank of Chile and LABORSTA. For Colombia the series are obtained from Banco de la República. For Mexico the series are obtained from OECD.stat. For Peru the series are obtained from INEI and LABORSTA. For the calibration

of the capital wedge $1 - \tau_{kt}$.

of the leisure parameter in the model I used total working hours provided by ILO LABORSTA data set.

C.4. Population

Working age population (age 15 and above) is obtained from the World Bank World Development Indicators (WDI).

C.5. Real Interest Rate

For Argentina, Brazil and Mexico I use the money market interest rate in domestic currency provided by the IMF International Financial Statistics (IFS). For Chile the money market interest rate is obtained from the Central Bank of Chile. For Colombia the interest rate is from the 90-day certificates obtained from Banco de la República. For Peru I use the money market interest rate in foreign currency published by the central bank of Peru. In addition, I multiply the foreign interest rate by the depreciation rate to express it in local currency. All the nominal interest rates were deflated by the CPI inflation in each country published in the IFS.

References

An, S. and F. Schorfheide, (2007), "Bayesian Analysis of DSGE Models," *Econometric Reviews,* 26, 113-172.

Bergoeing, R., P. Kehoe, T. Kehoe, and R. Soto, (2002), "A Decade Lost and Found: Mexico and Chile in the 1980s," *Review of Economic Dynamics*, 5, 166-205.

Basu, S. and M. Kimball, (1997),"Cyclical Productivity and Unobserved Input Variation," *NBER Working Paper* 5915.

Bernanke, B., M. Gertler, and S. Gilchrist (1999), "The Financial Accelerator in a Quantitative Business Cycle Framework," *Handbook of Macroeconomics*, Vol.1 edited by J. Taylor and M. Woodford. Amsterdam: North-Holland, 1341-1393

Braggion, F., Christiano, L., and J. Roldos, (2007), "Optimal Monetary Policy in a 'Sudden Stop'," *NBER Working Paper* 13254.

Bordo, M., C. Erceg, and C. Evans, (2000), "Money, Sticky Wages, and the Great Depression," *American Economic Review*, 90, 1447-1463.

Calvo, G., A. Izquierdo, and E. Talvi, (2006), "Phoenix Miracles in Emerging Markets: Recovering without Credit from Systemic Financial Crises," *NBER Working Paper* 1210.

Campbell, J. (1994), "Inspecting the mechanism: an analytical approach to the stochastic growth model," *Journal of Monetary Economics,* 33, 463-506.

Céspedes, L.F., R. Chang, and A. Velasco, (2004), "Balance Sheets and Exchange Rate Policy," *American Economic Review*, 94, 1183-1193.

Chari, V.V., P. Kehoe, and E. McGrattan, (2005), "Sudden Stops and Output Drops," *American Economic Review Papers and Proceedings*, 95, 381-387.

Chari, V.V., P. Kehoe, and E. McGrattan, (2007), "Business Cycle Accounting," *Econometrica,* 75, 781-836.

Christiano, L., C. Gust, and J. Roldos, (2004), "Monetary Policy in a Financial Crisis," *Journal of Economic Theory*, 119, 64-103.

Christiano, L. and J. Davis, (2006), "Two Flaws in Business Cycle Accounting," mimeo, Northwestern University.

Cole, H. and L. Ohanian, (1999), "The Great Depression in the United States from a Neoclassical Perspective," *Federal Reserve bank of Minneapolis Quarterly Review*, 23(Winter), 2-24.

Cole, H. and L. Ohanian, (2004), "New Deal Policies and the Persistence of the Great Depression: A General Equilibrium Analysis," *Journal of Political Economy*, 112, 779-816.

Correia, I., J. Neves, and S. Rebelo, (1995), "Business Cycles in a Small Open Economy," *European Economic Review,* 39, 1089-1113.

Galí, J., M. Gertler, and D. Lopez-Salido, (2007), "Markups, Gaps, and the Welfare Costs of Business Fluctuations," *Review of Economics and Statistics*, 89, 44-59.

Gertler, M., S. Gilchrist, and F. Natalucci, (2007), "External Constraints on Monetary Policy and the Financial Accelerator," *Journal of Money, Credit and Banking*, 39, 295-330.

Gollin D., (2002), "Getting Income Shares Right," *Journal of Political Economy*, 110, 458-474.

Greenwood, J., Z. Hercowitz, and G. Huffman, (1988), "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review*, 78, 402-417.

Heckman J. and C. Pages,(2000), "The Cost of Job Security Regulation: Evidence from Latin America," *NBER Working Paper* 7773.

Ireland, P., (2004), "A Method for Taking Models to the Data," *Journal of Economics Dynamics and Control*, 28, 1205-1226.

Kaminsky, G. and C. Reinhart, (1999), "The Twin Crises: The Causes of Banking and Balance-Of-Payments Problems," *American Economic Review*, 89, 473-500.

Kaminsky, G., C. Reinhart, C. Vegh, (2004), "When it Rains, it Pours: Procyclical Capital Flows and Macroeconomic Policies," *NBER Working Paper* 10780.

Kehoe, T. and E. Prescott, (2002), "Great Depressions of the 20th Century," *Review of Economic Dynamics*, 5, 1-18.

Kehoe, T. and K. Ruhl, (2008), "Sudden Stops, Sectoral Reallocations and the Real Exchange Rate," *Federal Reserve Bank of Minneapolis Staff Report* 414.

King R. and S. Rebelo (1999), "Resuscitating Real Business Cycles," *Handbook of Macroeconomics*, Vol.1 edited by J. Taylor and M. Woodford. Amsterdam: North-Holland, 927-1007.

Lagos, R., (2006), "A Model of TFP," *Review of Economic Studies*, 73, 983-1007.

Lane, P., and G.M. Milesi-Ferretti, (2006), "The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970-2004," *IMF Working Paper* WP/06/69.

McGrattan, E., (1994), "The Macroeconomic Effects of Distortionary Taxation," Journal of Monetary Economics, 33, 573-601.

Mendoza, E., (1991), "Real Business Cycle in a Small Open Economy," *American Economic Review*, 81, 797-818.

Mendoza, E., (2006), "Endogenous Sudden Stops in a Business Cycle Model with Collateral Constraints: A Fisherian Deflation of Tobin's Q," *NBER Working Paper* 12564.

Meza, F., (2008), "Financial Crisis, Fiscal Policy, and the 1995 GDP Contraction in Mexico," *Journal of Money, Credit, and Banking*, 40, 1239-1261.

Mulligan, C., (2002), "A Century of Labor-Leisure Distortions," *NBER Working Paper* 8774.

Neumeyer, P. and F. Perri, (2005), "Business Cycles in Emerging Economies: The Role of Interest Rates," *Journal of Monetary Economics,* 52, 345-380.

Nehru V. and A. Dhareshwar, (1993), "A New Database on Physical Capital Stock: Sources, Methodology and Results," *Revista de Analisis Economico*, 8, 37-59.

Ohanian, L., A. Raffo, and R. Rogerson, (2008), "Long-Term Changes in Labor Supply and Taxes: Evidence from OECD Countries, 1956-2004," *Journal of Monetary Economics,* 55, 1353-1362.

Primiceri, G., E. Schaumburg, and A. Tambalotti, (2006), "Intertemporal Disturbances," *NBER Working Paper* 12243.

Restuccia, D. and R. Rogerson, (2008), "Policy Distortions and Aggregate Productivity with Heterogenous Establishments," *Review of Economic Dynamics*, 11, 707-720.

Schmitt-Grohé, S. and M. Uribe, (2001), "Stabilization Policy and the Costs of Dollarization," *Journal of Money, Credit, and Banking*, 33, 482-509.

Schmitt-Grohé, S. and M. Uribe, (2003), "Closing Small Open Economy Models," *Journal of International Economics*, 61, 163-185.

Uribe, M. and V. Yue, (2006), "Country Spreads and Emerging Economies: Who Drives Whom?," *Journal of International Economics*, 69, 6-36.

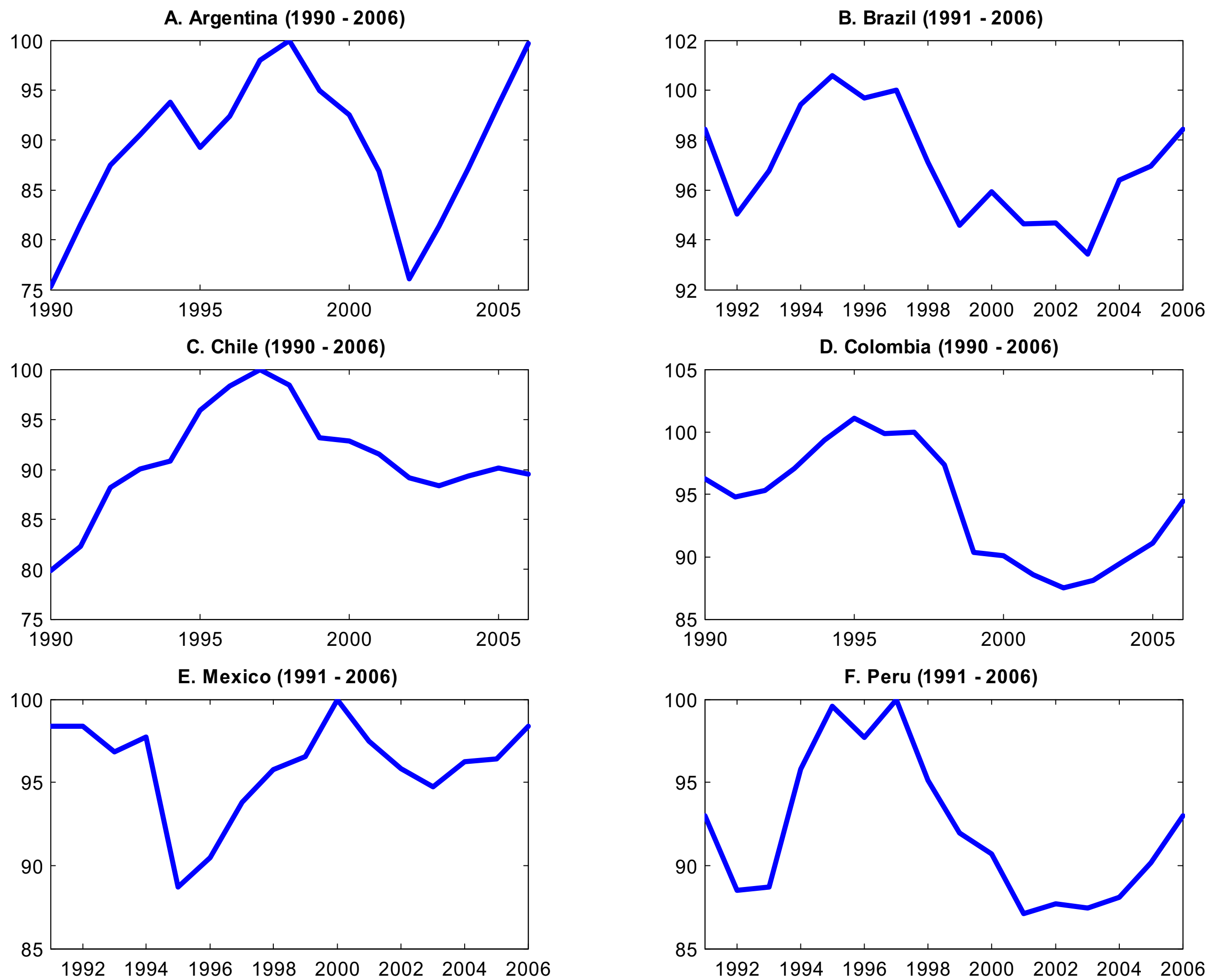

Figure 1: Detrended GDP per capita in Latin American economies.

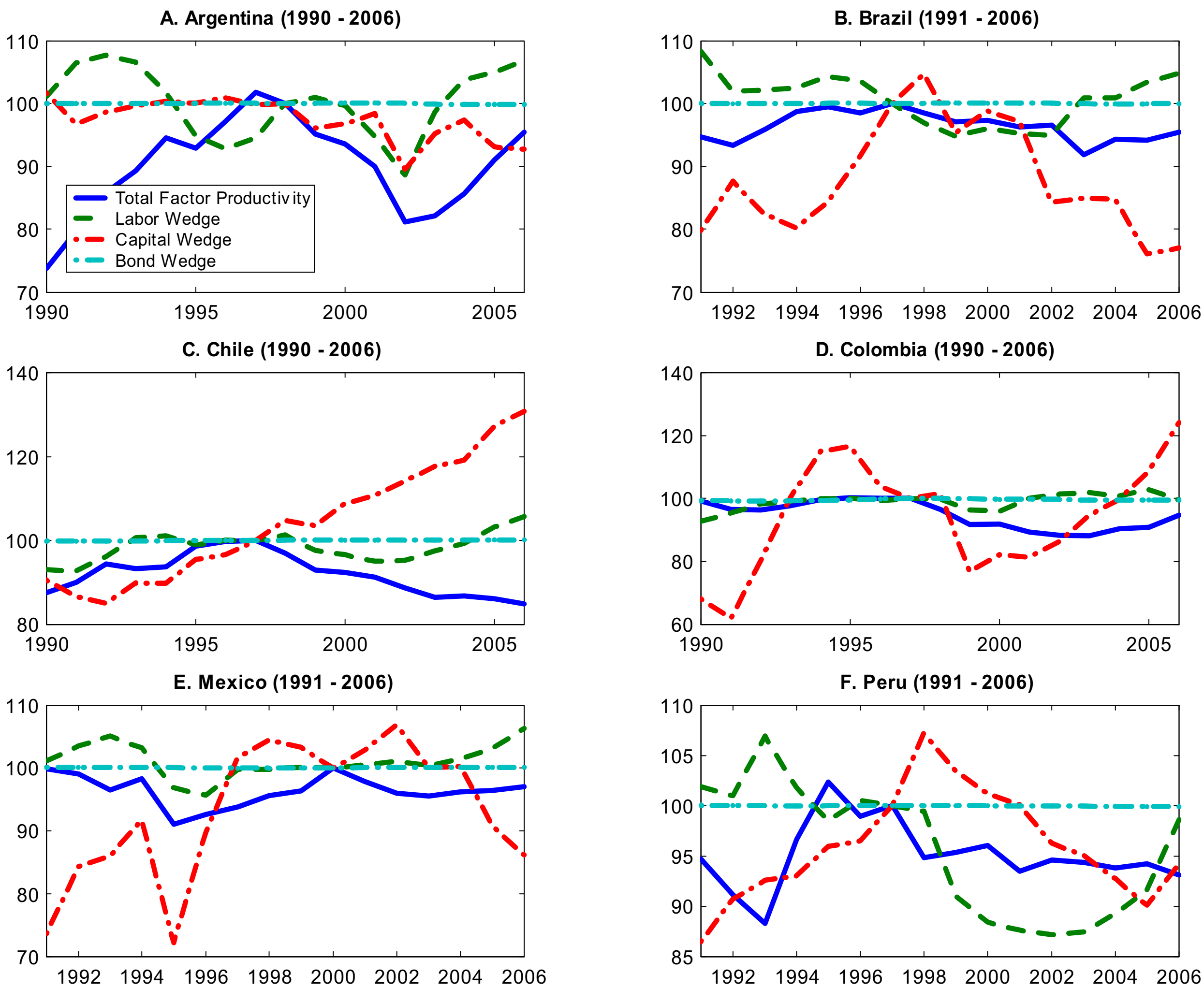

Figure 2: TFP, labor wedge, capital wedge, and bond wedge.

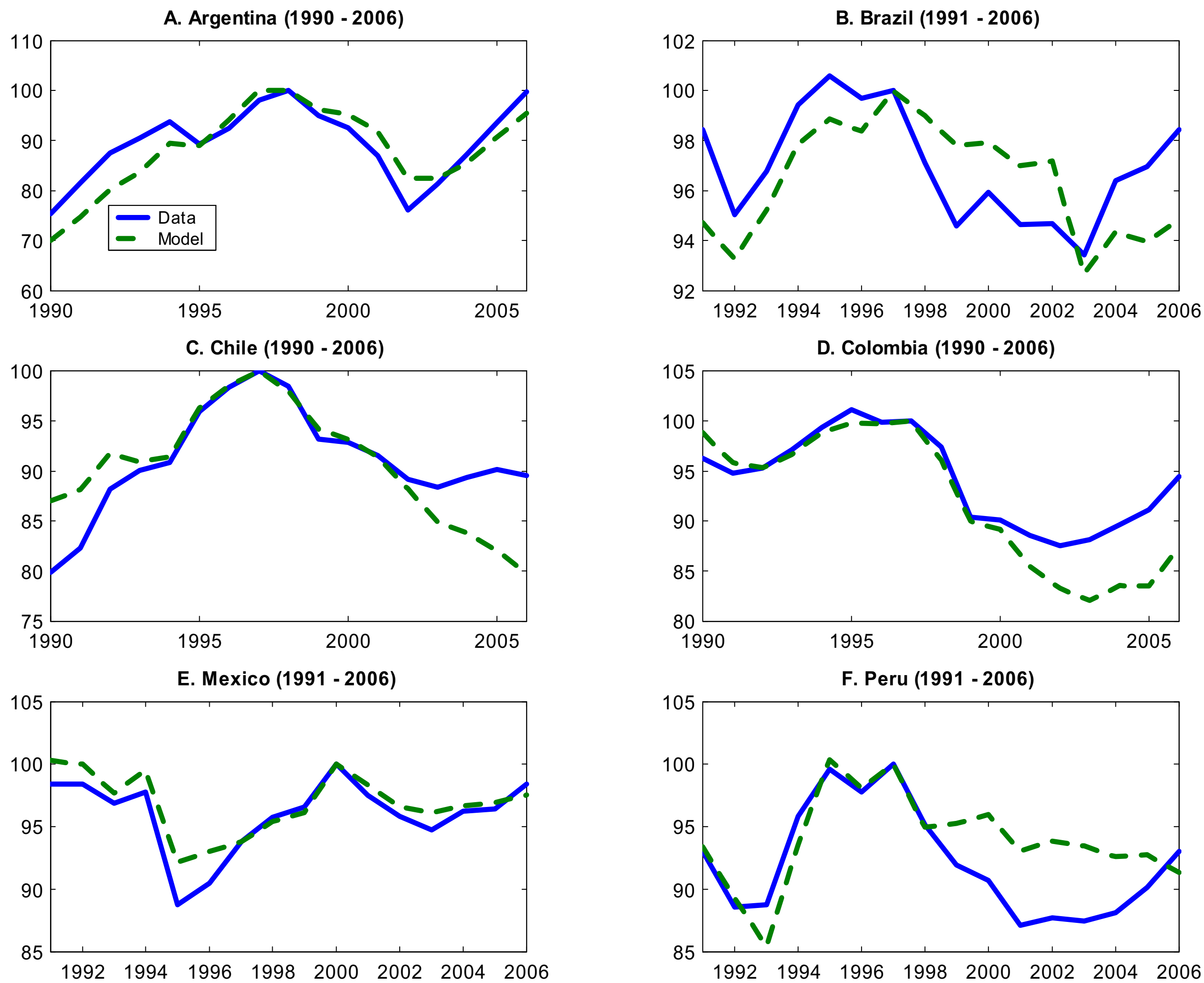

Figure 3: Effect of TFP on GDP.

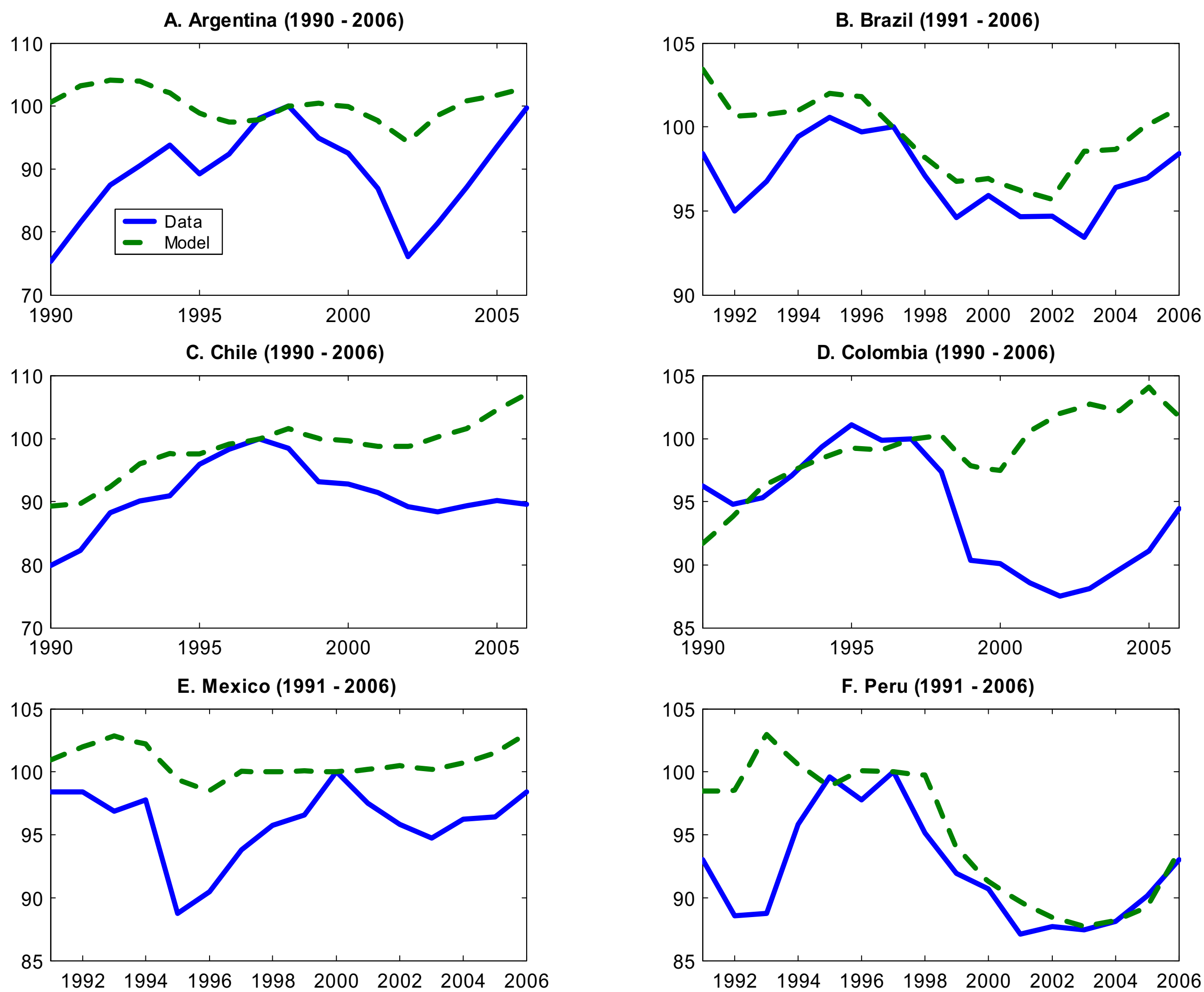

Figure 4: Effect of labor wedge on GDP.

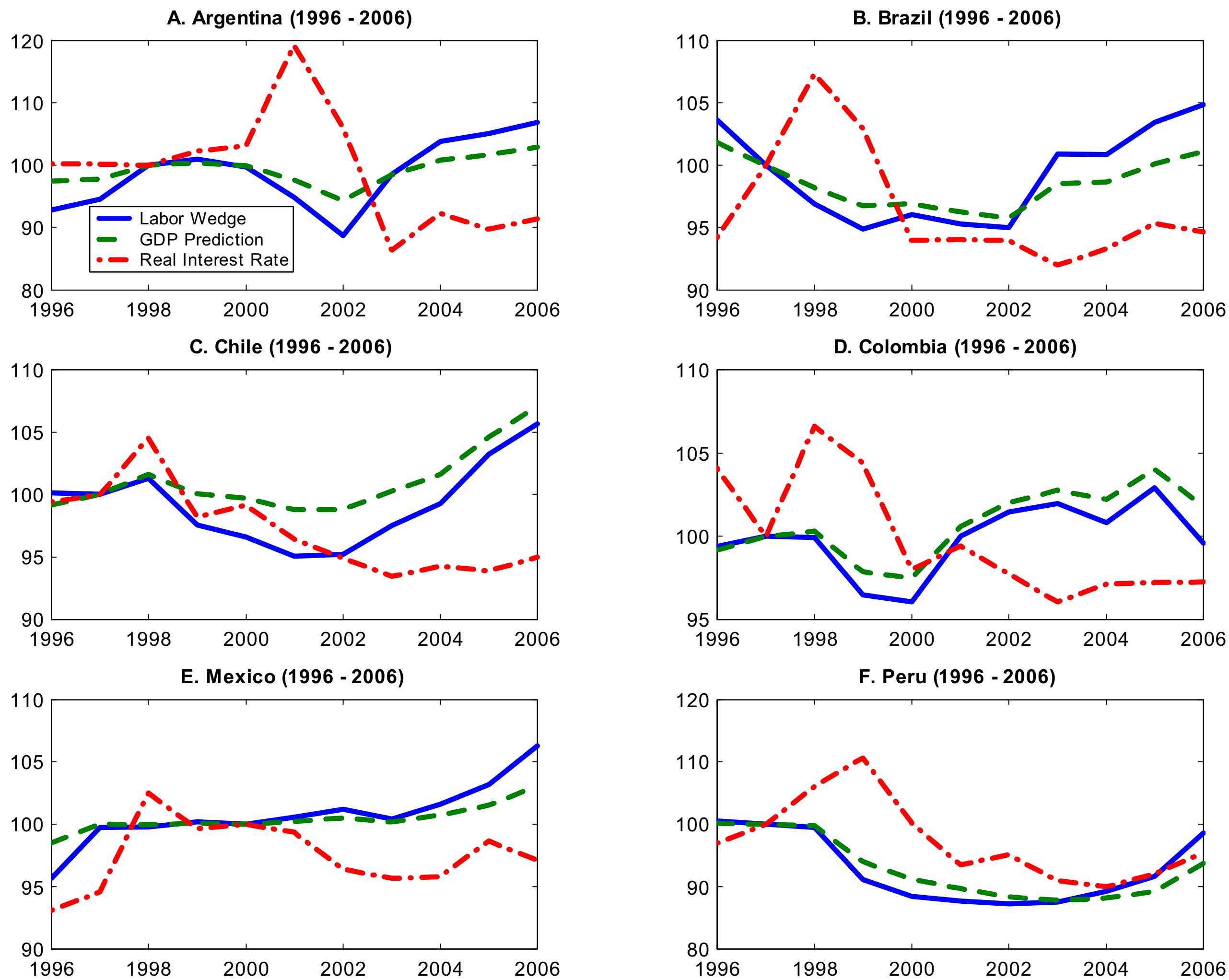

Figure 5: Labor wedge, model prediction, and real interest rate.

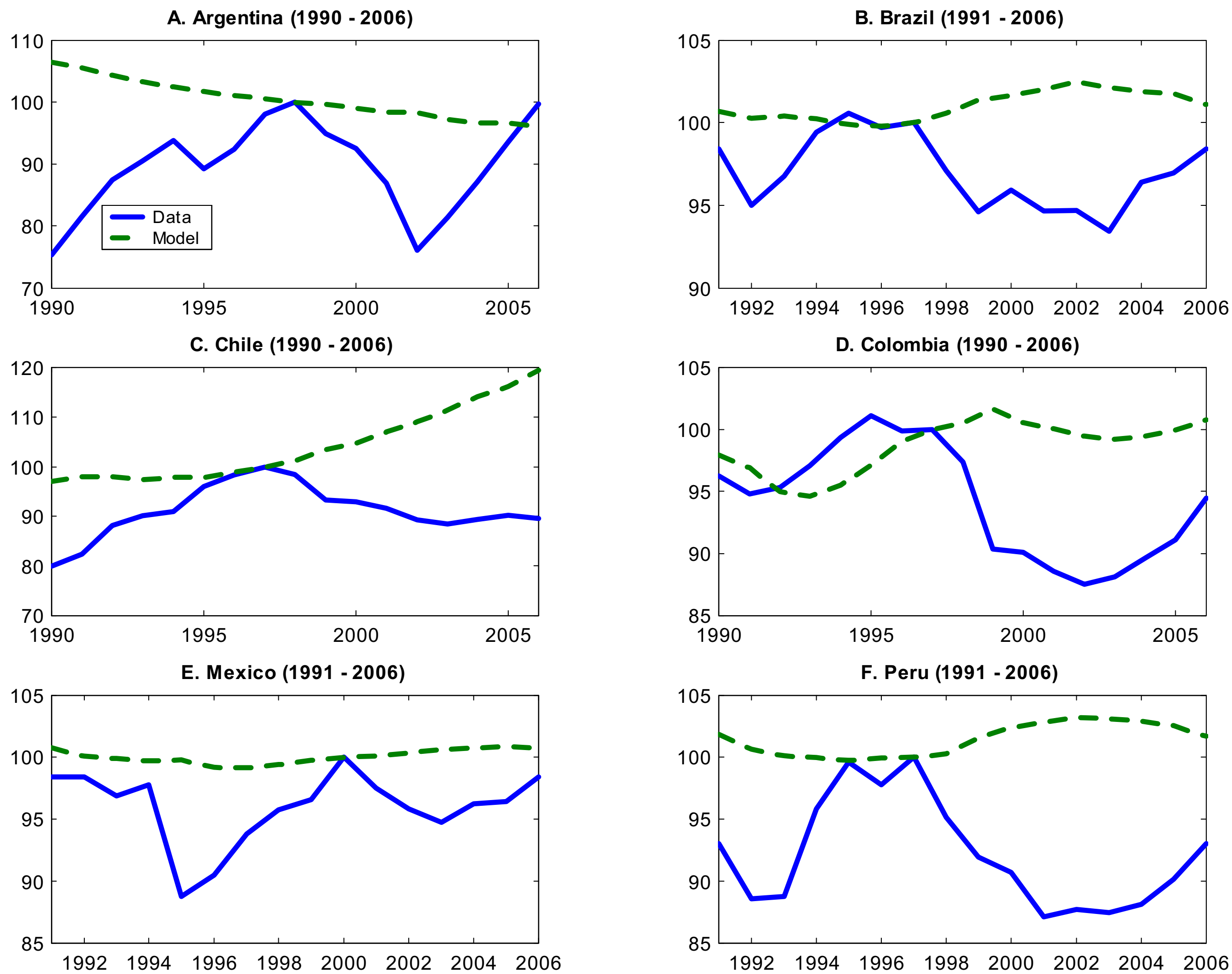

Figure 6: Effect of capital wedge on GDP.

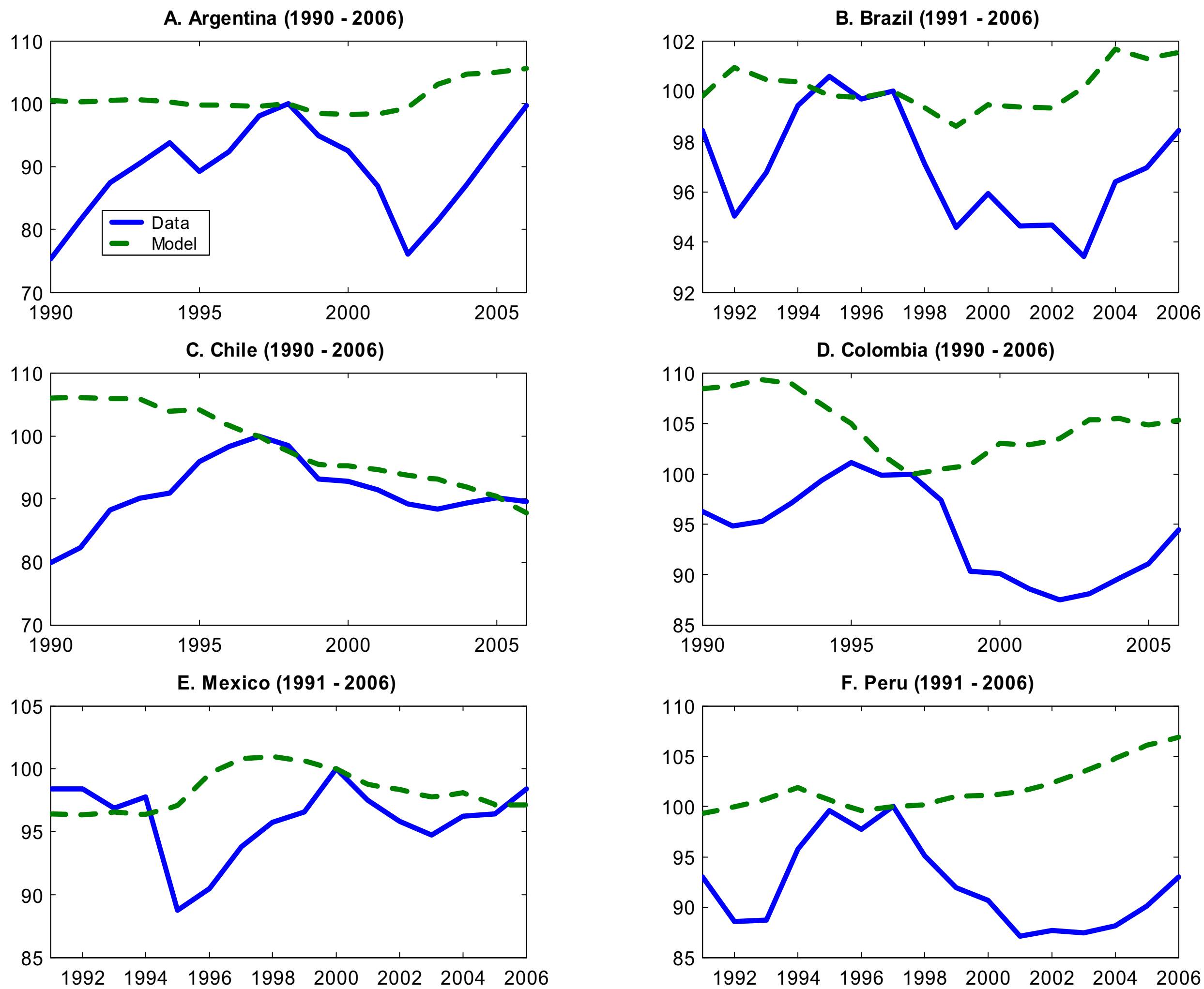

Figure 7: Effect of bond wedge on GDP.

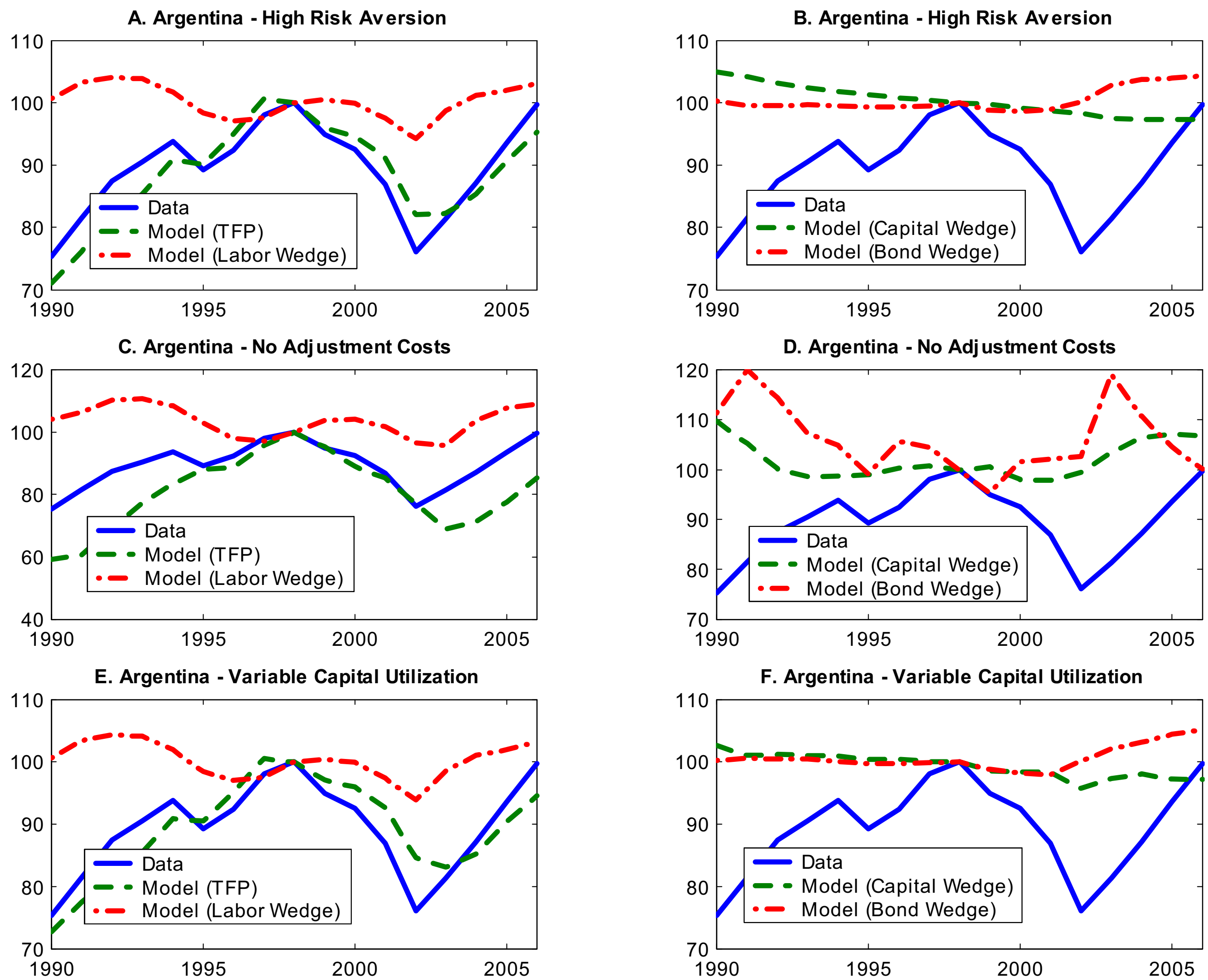

Figure 8: Sensitivity analysis.

Table 1

Calibrated Parameters

Parameter	Symbol	Argentina	Brazil	Mexico	Chile	Colombia	Peru
Discount factor	β	0.954	0.9317	0.947	0.921	0.925	0.936
Leisure weight	ψ	3.530	2.873	2.981	3.866	3.216	3.283
Technological progress growth	γ	0.34%	0.60%	0.71%	2.87%	0.91%	2.07%
Population growth	η	1.46%	2.17%	2.23%	2.09%	2.54%	2.29%
Capital adjustment costs	a	3.674	3.212	3.142	2.495	2.951	2.658

Table 2

Parameters of Stochastic Processes [1]

Wedges	Argentina	Brazil	Mexico	Chile	Colombia	Peru
AR(1) Coefficients						
Total Factor Productivity	0.987	0.992	0.989	0.991	0.980	0.988
	(0.002)	(0.003)	(0.003)	(0.002)	(0.007)	(0.002)
Labor wedge	0.995	0.990	0.994	0.989	0.964	0.985
	(0.003)	(0.005)	(0.005)	(0.004)	(0.019)	(0.004)
Capital wedge	0.884	0.733	0.593	0.934	0.779	0.891
	(0.051)	(0.168)	(0.262)	(0.036)	(0.121)	(0.140)
Bond wedge	0.994	0.979	0.996	0.992	0.917	0.999
	(0.009)	(0.059)	(0.007)	(0.015)	(0.099)	(0.004)
Standard Deviation						
Total Factor Productivity	0.047	0.019	0.024	0.040	0.020	0.034
	(0.006)	(0.003)	(0.004)	(0.005)	(0.003)	(0.006)
Labor wedge	0.041	0.026	0.023	0.039	0.020	0.037
	(0.005)	(0.005)	(0.004)	(0.005)	(0.003)	(0.006)
Capital wedge	0.052	0.067	0.094	0.052	0.112	0.032
	(0.016)	(0.046)	(0.086)	(0.012)	(0.055)	(0.021)
Bond wedge	0.000	0.000	0.000	0.001	0.001	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)

[1] Standard errors in parenthesis

Table 3

Contributions to Output Drops [1]

Wedges	Argentina (1998 - 2002)	Brazil (1997 - 2003)	Mexico (2000 - 2003)	Chile (1997 - 2003)	Colombia (1997 - 2002)	Peru (1997 - 2001)
Total Factor Productivity	-17.507	-7.314	-3.897	-15.042	-16.683	-6.938
Labor wedge	-5.587	-1.441	0.206	0.262	1.995	-10.290
Capital wedge	-1.657	2.128	0.648	11.370	-0.527	2.832
Bond wedge	-0.666	0.133	-2.247	-6.818	3.518	1.459
Output	-23.917	-6.581	-5.253	-11.602	-12.495	-12.897

[1] Percentage variation with respect to the base year

Table 4

Properties of Wedges

Wedge	S.D. Relative to Output	Cross Correlation of Wedge with GDP at lag k=				
		-2	-1	0	1	2
Argentina						
Total Factor Productivity	0.906	0.108	0.583	0.961	0.562	0.074
Labor wedge	0.661	-0.420	-0.013	0.399	0.226	-0.085
Capital wedge	0.826	0.201	0.366	0.238	0.017	-0.010
Bond wedge	0.007	-0.531	-0.320	0.007	0.246	0.400
Brazil						
Total Factor Productivity	0.888	0.296	0.428	0.786	0.207	-0.159
Labor wedge	1.340	-0.207	0.331	0.677	0.564	0.331
Capital wedge	3.243	0.595	0.315	-0.202	-0.497	-0.656
Bond wedge	0.013	-0.333	-0.140	0.259	0.501	0.601
Mexico						
Total Factor Productivity	0.802	0.065	0.419	0.967	0.308	-0.035
Labor wedge	0.747	-0.058	0.428	0.722	0.199	-0.425
Capital wedge	2.789	-0.184	-0.098	0.513	0.258	0.117
Bond wedge	0.011	-0.696	-0.632	-0.016	0.484	0.632
Chile						
Total Factor Productivity	0.867	0.396	0.752	0.951	0.641	0.261
Labor wedge	0.604	-0.185	0.203	0.622	0.550	0.346
Capital wedge	0.637	0.049	0.276	0.307	-0.152	-0.399
Bond wedge	0.008	-0.857	-0.645	-0.158	0.214	0.318
Colombia						
Total Factor Productivity	0.875	0.363	0.684	0.967	0.666	0.203
Labor wedge	0.647	-0.416	0.006	0.234	0.461	0.538
Capital wedge	5.010	-0.037	0.375	0.775	0.703	0.559
Bond wedge	0.058	-0.718	-0.684	-0.263	0.135	0.568
Peru						
Total Factor Productivity	0.798	-0.126	0.415	0.805	0.385	0.036
Labor wedge	1.030	0.138	0.337	0.530	0.661	0.451
Capital wedge	0.830	0.698	0.617	0.148	-0.173	-0.322
Bond wedge	0.003	-0.580	-0.623	-0.041	0.463	0.650

Table 5

Model Predictions

Model Prediction	S.D. Relative to Output	Cross Correlation of Wedge with GDP at lag k= -2	-1	0	1	2
Argentina						
Total Factor Productivity	0.952	0.254	0.667	0.930	0.465	-0.034
Labor wedge	0.299	-0.402	0.043	0.437	0.234	-0.077
Capital wedge	0.096	0.058	-0.152	-0.228	-0.186	-0.184
Bond wedge	0.219	-0.529	-0.305	0.029	0.266	0.414
Brazil						
Total Factor Productivity	0.791	0.405	0.450	0.684	0.021	-0.336
Labor wedge	0.742	-0.051	0.463	0.768	0.623	0.285
Capital wedge	0.264	-0.354	-0.713	-0.757	-0.604	-0.152
Bond wedge	0.299	-0.318	-0.106	0.298	0.525	0.610
Mexico						
Total Factor Productivity	0.776	0.189	0.503	0.946	0.198	-0.160
Labor wedge	0.338	0.011	0.435	0.625	0.049	-0.542
Capital wedge	0.111	0.502	0.699	0.271	0.115	-0.103
Bond wedge	0.376	-0.668	-0.553	0.068	0.544	0.653
Chile						
Total Factor Productivity	1.049	0.639	0.814	0.802	0.395	-0.044
Labor wedge	0.394	0.069	0.441	0.751	0.597	0.349
Capital wedge	0.195	-0.292	-0.514	-0.665	-0.416	0.028
Bond wedge	0.416	-0.768	-0.484	-0.018	0.332	0.460
Colombia						
Total Factor Productivity	1.046	0.509	0.768	0.937	0.536	0.029
Labor wedge	0.531	-0.288	0.140	0.304	0.465	0.496
Capital wedge	0.469	0.659	0.501	0.063	-0.363	-0.728
Bond wedge	0.596	-0.723	-0.700	-0.287	0.109	0.543
Peru						
Total Factor Productivity	0.869	0.051	0.541	0.773	0.239	-0.141
Labor wedge	0.748	0.301	0.481	0.615	0.660	0.340
Capital wedge	0.208	-0.121	-0.554	-0.699	-0.779	-0.563
Bond wedge	0.202	-0.611	-0.534	0.066	0.483	0.673